# SUCCESSFUL MECHANICAL SEAGRASS TRANSPLANTATION ON SUCCESS BANK, WESTERN AUSTRALIA

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## Introduction

The decline of seagrass meadows around population centres worldwide has caused much research to be directed into their rehabilitation, restoration and mitigation. Most transplant efforts to date have been carried out at a relatively small scale (< 1 ha) using manual methods. In the northern hemisphere, the relative success of these methods for small scale projects has been largely due to the properties of the seagrass species used (primarily *Zostera marina*). Until recently, very little success has been achieved in Australian efforts at transplantation. This has been due to their loss or removal by hydrological forces, epiphyte growth, fungal attack and/or grazing by sea urchins. In Western Australia, of the 7,500 transplant units that have been placed within the Perth Metropolitan region, most have been lost due to water motion. It was determined therefore that to make restoration a viable option, larger transplant units were necessary (to ensure high survival rates) along with the capability to restore a sufficiently large area. The only feasible option therefore was to construct a mechanical device to extract and plant seagrass. Manual methods of transplantation have been carried out to provide data to aid in site selection for mechanical transplantation.

## Materials and methods

### *Manual*

In the first series of experiments, plugs of *Amphibolis griffithii* (Black) den Hartog) were removed from a monospecific meadow on Success Bank, Western Australia and placed at four sites each of a different depth (5, 6, 8 and 10 m). Plugs consisted of the whole plant, including leaf blades, roots, rhizome and the surrounding sediment intact. These were extracted using 200 mm lengths of PVC piping 15 cm in diameter (176.7 cm$^2$) sharpened at one end. Piping bases were capped with plastic sewer lids to minimise rhizome and root disturbance. Forty five plugs were placed at each site. Control treatment consisted of excavating a plug, removing it from the sediment and then replacing it in its original position (45 plugs). At the recipient sites, holes were excavated to receive the plugs, the caps removed, the plug placed in the hole and the piping removed. To take account of variation within each depth, this experiment was replicated a year later to add a further two sites to each depth (with the same number of plugs at each experimental site). Plugs were monitored for survival, shoot density and effect of fertiliser addition (fertiliser spikes added randomly to 20 of the 45 plugs in each treatment).

### *Mechanical*

An underwater seagrass harvesting and planting machine ('ECOSUB1', Figure 1) was designed with the specific parameters that a large seagrass 'sod' (0.25 m$^2$ in area and 0.5 m deep) could be extracted and planted with minimal disturbance to the leaves, roots and rhizomes contained within it. A prototype was developed and tested by the end of September 1996 and transplantation commenced on November 1996. The machine consists of a frame with four wheels that is self-winched across the ocean floor, it contains a cutting head with forward vibrating teeth, powered by a hydraulic ram. The cutting head is fitted with an open-ended cartridge which, when filled with seagrass, is extracted and placed into an onboard hopper. The hopper can now store nine sods before the machine is raised on its own buoyancy tanks and moved to the planting site. The prototype has undergone major modifications since its first deployment and is now capable of cutting and extracting a seagrass sod in less than 10 minutes. 1,000 sods have been successfully extracted and planted since November 1996 to the present. A range of species has been transplanted; monospecific *Posidonia sinuosa* Cambridge and Kuo, *P. coriacea*, *A. griffithii* and a mixture of the latter two species. Monitoring consists of survival, shoot density, cover changes, species changes, spreading rate and seedling settlement. Control *P. coriacea* and *A. griffithii* beds were established to provide information on shoot density changes.

**Figure 1.** ECOSUB1.

**Results**

***Manual***

The initial depth trial sites, established in February 1997, have been monitored regularly over the past 14 months, and the triplicated sites have been monitored twice since they were established in December 1997. A steady decline in plug survival was observed for all treatments, with a decline of 55 - 60 % for all treatments except at 5 m, which appears to have steadied at approximately 60 % survival (Figure 2).

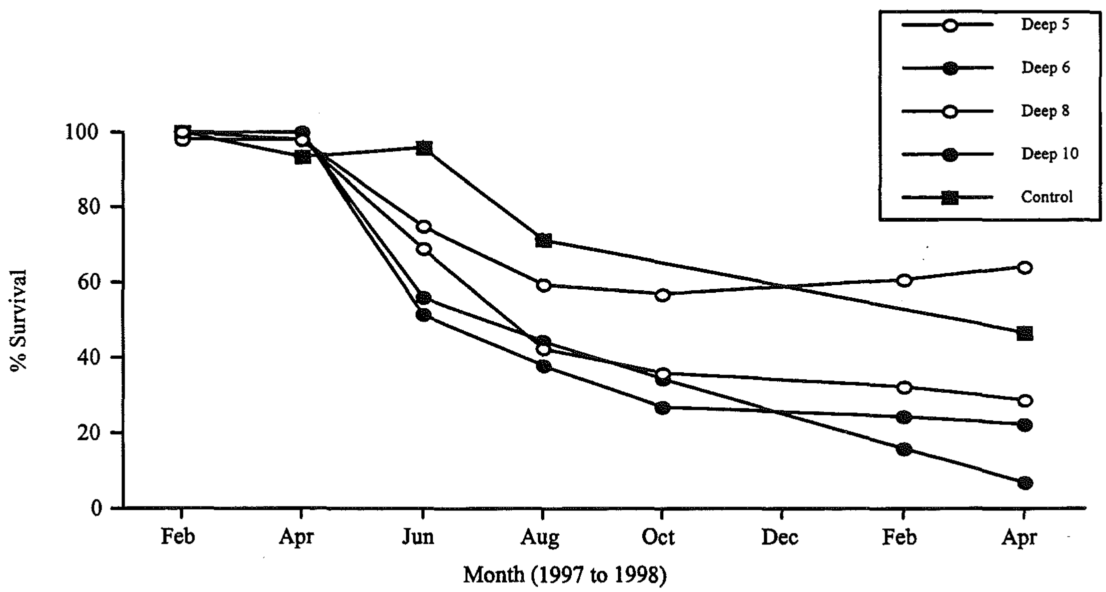


**Figure 2.** Percent survival of plugs planted at depths of 5, 6, 8 and 10 m over a fourteen month period at the first of the triplicate sites in comparison to control plugs. Sods were planted in February 1997.

The control treatments showed a decline of approximately 30 % over the first six months of monitoring. The observed decline within the first four months after transplantation corresponded to the onset of the winter storms. There appeared to be a lag in the decline of the control treatment, possibly reflecting the protection of the dense seagrass meadow that surrounds these plugs. The recent triplicated treatments have also shown a decline in survival of approximately 5 to 20 % depending upon depth.

The experimental treatments all showed a decline in shoot numbers of between 25 and 60 % during the initial six months, again corresponding with the onset of winter. Following this decline however, shoot numbers remained fairly constant for all treatments except at 5 m, which showed a marked increase in shoot numbers. The data from the 5 m treatment suggest that the seagrasses are following a seasonal pattern, with a decline in shoot numbers during winter, followed by an increase in spring and summer. While the other treatments have not exhibited the same increase in shoot numbers over summer, they have not declined further, indicating some stability in growth pattern. Data from the control site has not been fully analysed but initial results show a similar decline in shoot density. Monitoring and analysis of plugs which had fertiliser applications indicated that there were no significant differences in shoot numbers between fertilised and unfertilised plugs at all depth treatments, at both five and nine months following treatment.

***Mechanical***

Approximately 85 % of the mechanically transplanted sods had survived after five months, and this value remained unchanged after 15 months (Figure 3).

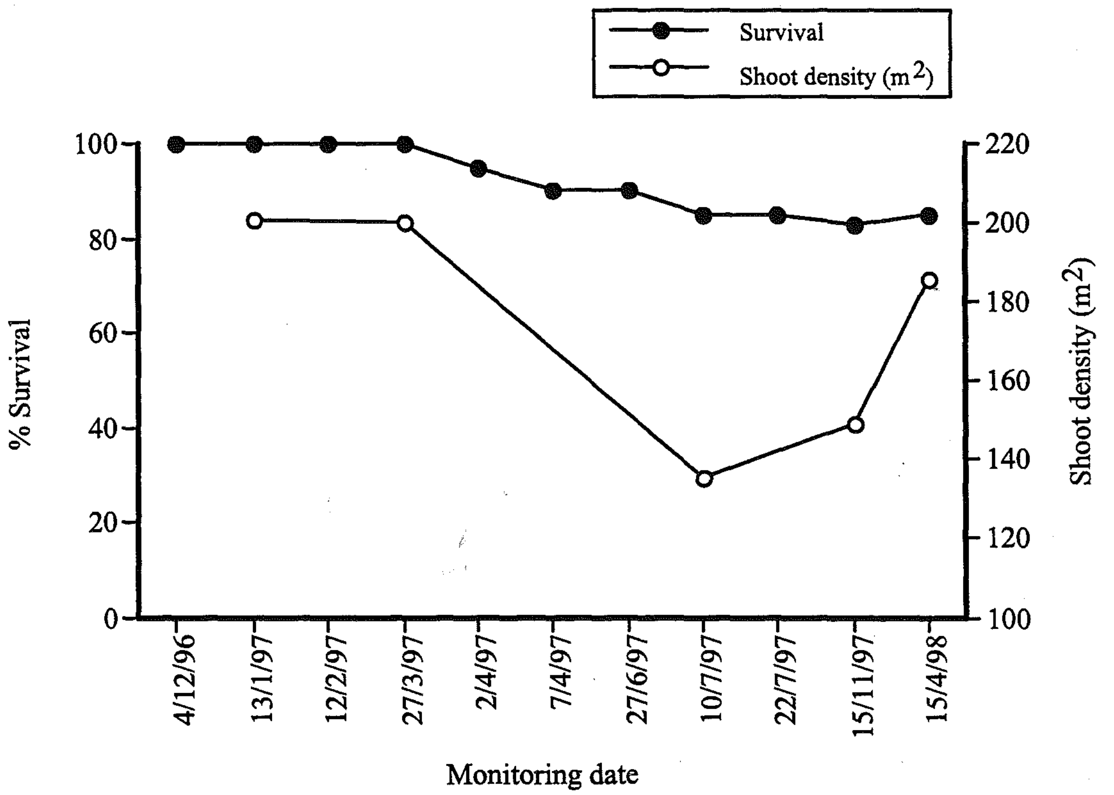


**Figure 3.** Percent survival and shoot density in mechanically transplanted sods.

Shoot densities in general showed a decline in winter followed by an increase in the following summer. Percentage change in shoot densities in the transplanted sods (from 10 to 70 %, measured every three months) exhibited a greater variation in comparison to control meadows of *P. coriacea* and *A. griffithii* (5 and 40 % respectively over 15 months).

Spreading was observed in *P. sinuosa* sods at the recipient site. In some cases rhizomes up to 30 cm in length were recorded. A subsample of 80 sods was randomly selected from a possible 230 planted (35 % of the population), these being the longest in place (between 10 and 17 months). Of these 80 sods, 28 (35 %) showed signs of spreading with a mean rhizome length of 10.4 cm. Taking into account the individual variation, the standard deviation of the extension rates was 6.8 cm. This equates to a range of monthly extension rates of 0.5 to 1.76 cm per month or 6 to 21 cm per year.

Numerous *Posidonia sinuosa* seedlings were observed at the recipient site in April 1998. Approximately 1,000 seedlings were found amongst transplanted sods in all parts of the site, but not in adjacent bare sand areas. It is not possible to accurately determine the age of the seedlings, however it is estimated that they are at least 10 months old. Some seedlings had three or four leaves present, to a length of approximately 20 cm, and root lengths of 10 - 20 cm were observed. Most seedlings appeared well anchored within the sediment, and were identified as seedlings only by the presence of a testa, at some depth below the sediment level.

**Discussion**

It is clear from preliminary results that mechanical transplantation is a feasible option for replanting seagrass meadows. Particularly since the design and manufacture of a machine designed to be able to transplant up to 40 $m^2$ per day is now underway and expected to be trialed in January 1999. Data from manual experiments, specifically growth of surviving plugs, suggests strongly that there is the possibility of placing mechanically transplanted sods in deeper depths. This has many ramifications for the rehabilitation of dredged areas and also provides additional areas in which seagrass may be transplanted. That certain Western Australian seagrass species appear to be able to survive transplanting from shallow to deeper depths illustrates a plasticity of physiological response not noted in other species in the world. The presence of seedling settlement in mechanically transplanted areas is also encouraging and may provide a return of seagrass functional attributes more rapidly than by sod planting alone.